DETERMINE PHYSICAL PROPERTIES OF AN ORGANIC CITRIC ACID (PROCESSED LIME JUICE) DISSOLVE WITH WATER USING EXPERIMENTAL APPARATUS

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***Abstract*—This paper describes experimental studies on the physical properties of processed lime juice to dissolve with water. Lime juice as known as organic citric acid have many advantages in our life especially in food industries, pharmaceutical industries, anticancer and antioxidant and cleaning agent. Physical properties of liquid include pH, viscosity, density, molar mass and surface tension. This Study conducted using common laboratory apparatus such as Pycnometer, the pH device (HI 9811 pH), Viscolite700 etc. The additional organic citric acid by percentage in water was changed the physical properties of liquids. The future strategy of this research is to introduce organic lime juice mixed with water in spray system as cleaning agent, reduce air pollution and reduce water consumption for Commercial Restaurant Equipment.**

Keyword-Processed Lime Juice, Organic Citric Acid, Water, Spray

I. INTRODUCTION

Citric acid also known as 2-hydroxypropane-1,2,3-tricarboxylic acid with 192.12 g mol− 1 (C6H8O7, CAS No. 77-92-9) is weak organic and naturally use as the natural preservative [1][2]. Citric acid is a common metabolite of plant and animals. It is also the most widely and versatile use organic acid in food and pharmaceutical industries. In 2004, citric acids usage in U.S is about 64% for the foods and beverages, for the detergents and cleaning products it takes 22% and for the pharmaceutical and nutritional products it takes 10% and another 2% goes into the cosmetics and toiletries [3]. According to U.C. Nwaogu 2010, citric acid is a good cleaning agent for Magnesium alloy and it's exposed the poorest removal of an iron layer from the surface better than Oxalic acid and acetic acid [4]. Citric acid is suitable for cleaning in food industries, corroded steel surfaces [5][6].

For the flavouring and preservative in food and beverages, the citric acids as the distinctive sharp taste and it is found in the juice of lemons and other sour fruits [7]. Citric acids also play the important role for cure the health disease and prevention of the disease. It can cut the cardiovascular diseases, cataracts, the risk of cancer and some functional diseases [8]. The main production countries for the citric acids according to the FAO (2008) are Brazil, China and the United States, followed by Spain, Italy and Mexico. Brazil is the first world producer of oranges and lemons by species according to conventional tillage, followed by the United States. For China is produces for the tangerines [9]. Nowadays, water consumption is one of the crises in the world. The population growth in regions will occur the experiencing the water stress. The water pollution will facilitate the human disease and will diminish water quality. For the water contents that being use, the living organisms range from 60% to 95%, human are about 60%. The increase of water pollution can reduce water sources and as a threat to the health of the environment. It will contribute the higher costs for water treatment. [10]. Due to these challenges, the alternative way to reduce the water consumption is to mix the water with Lime juice for future study in spray cleaning or cooling process in kitchen hood ventilation system.

II. METHODHOLOGY

This research was used processed lime juice for cooking and produced by LengHeng Agri-Foods Co.Ltd as shown as in Fig. 1. Six samples has been used with the amount of 40 ml and ambient temperature at 28oC with 1 atm. The sample is pure organic citric acid (L100), water (L0), L10 is 10% of organic citric acid (4 ml) mixed with 90% water (36 ml), L20, L30, L40 and L50. Here, determine five properties of liquid. There are pH, viscosity, density, molar mass and surface tension.

Fig. 1. Artificial Flavor Lime Juice (http://www.lenghengfoods.com/products-17.html)

A. Determine pH Value of Lime Juice Dissolve with Water

The letters of pH stand for "power of hydrogen or potential of hydrogen". pH is a substance that is neither acidity nor basicity (alkalinity) is neutral. The pH scale measures are ranges from 0 to 14 where a pH of 7 is neutral. A pH less than 7 is acidity, and a pH greater than 7 is basicity or alkalinity.

Fig.2 shows that the filtering process to find pH for pure lime juice. This testing was exposed to study the acidity of lime juice. The device for determine the pH is HI 9811 pH/ EC/ TDS meter. This device is designed for the liquid application only.

Fig. 2. pH apparatus (HI 9811 pH/ EC/ TDS).

First steps to measure the pH value is connect the HI1285-0 probe. ON the switch meter, then submerge the probe into the test tube with liquid. Select the unit measurement range (pH, µS/cm, and mg/L) by pressing the correspondent key. Next, wait for a few minutes for reach the thermal equilibrium before proceeding any measurements. After use, switch off and clean and dry the probe.

Note: *If the display shows a "1", the meter is out of range.*

Note: *It is recommended to clean often the probe with* ***HI700661*** *Cleaning Solution.*

B. Determine Viscosity of Lime Juice or Organic Citric Acid Dissolve with Water

Viscosity of liquid is the thickness of a liquid or resistance of a liquid to shear forces. Viscosity can be define by two-way: Dynamic viscosity, also call absolute viscosity, the SI unit is Pascal seconds (Pa.s) or Poise (P)or Centipoise (cP), and Kinematic viscosity is the dynamic viscosity divided by the density (SI units' m^2/s or Stokes, St).The viscosity device to determine dynamic viscosity of liquid as shown as in Fig.3. The apparatus to determine liquid viscosity is Viscolite700. The Viscolite700 is an advanced portable viscometer with stainless-steel probe. The operating range is between 0.1~10,000 centipoise (cP) with integral temperature correction (-40~150°C).

Note*: 1cP = 0.01P = 0.001 kg/m-s (Pa.s).*

First step, switch ON the Viscolite700. After that, the sensor must be clean and the instrument monitor should be ZERO. Put the sensor into the beaker filled with liquid (water or Lime Juice). Make sure, the probe must be properly clamped. Select the menu measurement range (VL for live viscosity reading, VC for viscosity corrected to reference temperature and t for fluid temperature) then press the correspondent button. After that, wait for a few second until the reading is stable and take the reading. Lastly, switch OFF Viscolite700, then wipe and clean the probe.

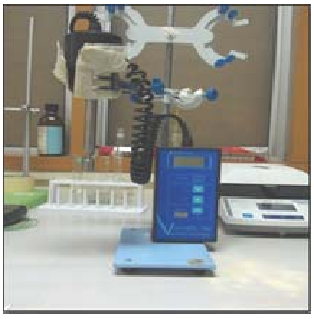


Fig. 3. Viscosity testing apparatus**.**

C. Density Determination of a Lime Juice Dissolve with Water using Pycnometers

Density determination of a lime juice dissolve with water using by Pycnometer method. Density is the ratio of a mass of substance to its volume. The SI unit is kg/m^3. The Pycnometer made according to Gay-Lussac, DIN 12 797 as shown as in Fig.4 (b). A Pycnometer is a glass with a precisely determined volume, used for determining both the density of liquids and dispersion by simply weighing the defined volume (Manual of Weighing Applications by Sartorius Comp.). The volume of Pycnometer in this study is 25.063ml.

The procedure is as follows:

- First the Pycnometer is emptied, cleaned, dried and determine the weight of Pycnometer using the Semi-Micro Balances (See Fig.4 (c)) and set the weighing to ZERO.
- Next, take the temperature of the lime juice using the thermometer as shown in Fig.4 (a). After that, the Pycnometer is filled to about 2/3 with the sample (lime juice) see Figure-3(b) and take the weight as shown in Figure-3(c).
- The Pycnometer is clean very carefully after finishes do the experiment. Use the distilled water to rinse and dry it. Lastly, use the principle $\rho = \frac{m}{v}$ to determine the density.

(a) (b) (c)

Fig. 4 Pycnometer testing apparatus (a) Put thermometer at Sample (b) Sample filled at Pycnometer (c) Put sample at Semi-Micro Balances.

Example:

Calculate density for L10:

Density, ρ = mass (kg) / Volume (m^3)

= 0.0249988 (kg) / 2.5063E^{-5} (m^3)

= 997.44 kg/m^3

Calculate density for L30:

Density, ρ = mass (kg) / Volume (m^3)
= 0.0251032 (kg) / 2.5063E^{-5} (m^3)
= 1001.60 kg/m^3

D. Determine of Molar Mass in Liquid Properties

The molar mass, M is a chemical element or chemical compound of the substance as the mass divided by the amount of substance. The SI unit for molar mass is kg/mol. To determine the molar mass for this study is firstly define the physical property for organic citric acid ($C_6H_8O_7$) and water (H_2O). Table I shows that the physical property of the Citric Acid and Table II shows that the physical property of Water (sources periodic table of elements).

TABLE I. PHYSICAL PROPERTY OF THE CITRIC ACID ($C_6H_8O_7$)

Element	Atom Weight (g/mol)	Atoms
Hydrogen	1.00974	8
Carbon	12.0107	6
Oxygen	15.9994	7

TABLE III. PHYSICAL PROPERTY OF THE WATER (H_2O)

Element	Atom Weight (g/mol)	Atoms
Hydrogen	1.00974	2
Oxygen	15.9994	1

To calculate the Molar masses of chemical compounds are equal to the sums of the molar masses of all the atoms in one molecule of that compound. For example, chemical compound such as organic citric acid, the molar mass will be equal to the molar mass of eight atoms of hydrogen plus the molar mass of six atoms of carbon and plus seven atoms of oxygen. It can write this as a calculation of the organic citric acid, water and L10 molar mass as follow:

<u>Organic citric acid</u>

$C_6H_8O_7$ = (C * 6) + (H * 8) + (O * 7)
= (12.0107g/mol * 6) + (1.00794g/mol * 8) + (15.9994g/mol * 7)
= 192.1235 g/mol.

<u>Water</u>

H_2O = (H * 2) + (O * 1)
= (1.00794 g/mol *2) + (15.9994 g/mol *1)
= 18.01528 g/mol.

<u>L10</u>

10% C6H8O7 + 90% H2O
= 10/100(192.1235g/mol) + 90/100 (18.01528 g/mol)
= 19.21235 g/mol + 16.2 g/mol
= 35.41235 g/mol.

E. Determination of the Surface Tension of a Liquid Using the Drop-weight Method

The surface tension of water is measured as the wall tension for the development bubbles in the water or energy essential to a surface area of a liquid divided by a unit of area. The SI unit is N/m. In this study, to determine of surface tension of a liquid using Drop-weight method. This method compare the surface tension between of two liquid using this Eqn. (1):

$$\frac{\sigma_1}{\sigma_2} = \frac{m_1}{m_2} \quad (1)$$

σ_1 = Surface tension for liquid (organic Citric acid & organic Citric acid dissolve with water) at 28°C

σ_2 = Surface tension for 100% of water at 28°C

m_1 = Net Mass for liquid (organic Citric acid & organic Citric acid dissolve with water) at 28°C (take average for three data)

m_2 = Net Mass for 100% of water at 28°C

Ambient temperature in this study is 28°C. The surface tension for water (σ_2) at 28°C is 7.152 E^{-2} N/m (Sources Fluid Mechanics, 3rd edition–Yunus A.Cengel). The first step, take mass for empty beaker using Semi-Micro Balance. Then, determine mass for 30 droplets of water in the beaker using a burette and calculate the net mass for 30 droplets of water (m_2). The second step, determine the net mass of 30 droplets for organic citric acid (m_1) by following step 1. Finally using Eqns. (1) to get σ_1.

Example:

$$\frac{\sigma_1}{\sigma_2} = \frac{m_1}{m_2}$$

$\sigma_2 = 7.152\ E^{-2}$ N/m,

$m_2 = 1.794$ g,

$m_1 = 1.7811$g

So,

$\sigma_1 = 7.1006E^{-2}$ N/m

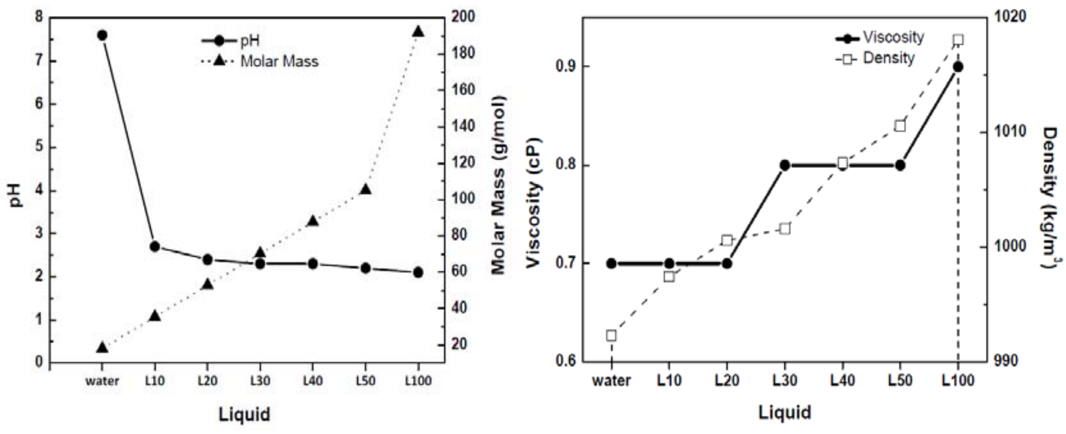
III. RESULT

Table III, present the liquid properties of water and organic citric acid (processed lime juice) dissolve with water at 28°C. The pH value of water definitely high compare with acid, but increasing of water content in citric acid will increase pH value. For example, 70% of water content with 30% organic citric acid the pH value is 2.4 if compared with 100% organic citric acid. The additional organic citric acid to water will reduce the molar mass value. Fig.5 (a) show that the molar mass value for the liquid. It can explain that increase of pH value will decrease the molar mass of substances.

However, Fig.5 (b) illustrates the viscosity and density of organic lime juice higher than water. The highest value of density and viscosity is 1018.08 kg/m^3 and 0.9 cP for L100. The additional of organic citric acid in water give affects in the liquid properties. Main factor is increasing of molar mass in additional of organic citric acid. The concentration of organic citric acid provides low surface tension while high molar mass, density and viscosity as in Fig.5 & Fig.6. The surface tension is used to determine its accuracy or quality the purity of liquids. Water and L100 have different liquid properties and nature.

TABLE IIII. Result for Liquid Properties for Organic Citric Acid (Lime Juice) Dissolve with Water.

Organic citric acid (%)	Water (%)	Nomenclature	T(°C)	pH	M (g/mol)	μ (cP)	ρ (kg/m^3)	σ (N/m)
0	100	L0	28	7.6	18.02	0.7	992.33	7.15E^{-2}
10	90	L10		2.7	35.41	0.7	997.44	7.10E^{-2}
20	70	L20		2.4	52.84	0.7	1000.60	7.09E^{-2}
30	80	L30		2.3	70.25	0.8	1001.60	7.06E^{-2}
40	60	L40		2.3	87.66	0.8	1007.35	7.02E^{-2}
50	50	L50		2.2	105.07	0.8	1010.56	6.97E^{-2}
100	0	L100		2.1	192.12	0.9	1018.08	6.39E^{-2}



(a) (b)

Fig. 5, (a) pH and molar mass (b) Viscosity and density of water and organic citric acid dissolve with water at T=28°C

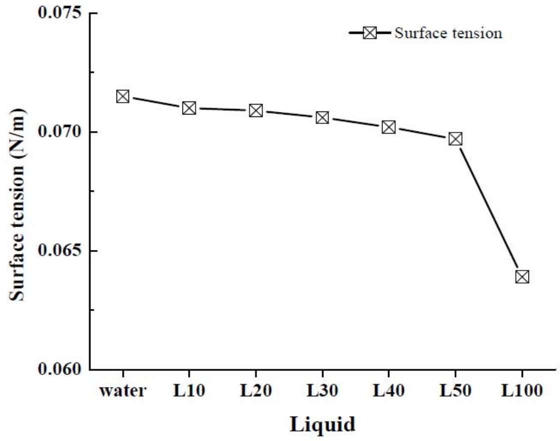


Fig. 6.Surface tension for water and organic citric acid dissolve with water at T=28^{o}C

IV. CONCLUSIONS

Five experiments have been done to determine water and organic lime juice properties. Water and organic citric acid are different type of liquids in term of psychical properties and is especially molar mass, pH value and surface tension. But additional organic citric acid by percentage of water give slightly change except for pH value. Liquid properties are very important to determine the penetration, spray angle, velocity and droplet size. It will affect the viscosity, surface tension, pH value and density. The different liquid properties will produce the different spray behavior.

V. FUTURE SCOPE

This study is for the future scope to implement processed lime juice dissolve with water for cleaning and cooling spray in the cooking process. Citric acid is suitable for cleaning and removes oil and grease when cooking process. A good starting point is to recognize the liquid properties for development spray system in the Kitchen Ventilation Exhaust.

VI. ACKNOWLEDGEMENTS

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